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When prosody matters!
Emerging word segmentation abilities in European Portuguese learning infants

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Introduction

The word segmentation problem: when and how infants begin to segment word-like forms from the continuous speech stream?

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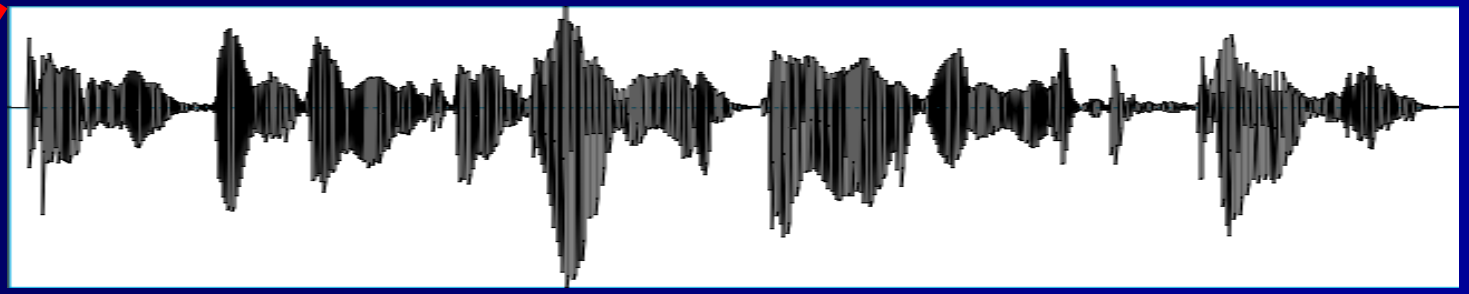
CHALLENGE !



- Early word segmentation plays a crucial role in language acquisition (i.e., word learning, syntax – Newman et al., 2006; Singh et al., 2012)

Introduction

- Segmentation abilities in typically developing infants have been shown to vary across languages (e.g., Jusczyk & Aslin, 1995; Jusczyk et al., 1999; Seidl & Johnson, 2006; Hohle & Weissenborn, 2003, 2005; Bosch et al, 2013; Nazzi et al., 2006; Mersad at al., 2010; Nazzi et al., 2014)

	Monosyllabic	Bisyllabic	
		Trochaic	Iambic
English	7.5m	7.5m	10.5m
German	7-9m	9m	11m+
Spanish/Catalan	6m		
French	7.5m?	-	16m?/8m?

Introduction

- Rhythmic properties of a language (i.e., stress based, syllable based) may be utilised to begin segmenting continuous speech – what the infant relies on (Nazzi et al. 2006)
- Word position may be crucial also due to prosody: Words at utterance edges/boundaries easier to segment than those in the middle (Seidl & Johnson, 2006; Johnson et al., 2014)
  - Edge provides particularly **salient cues** e.g. duration and pitch cues

Language	Rhythm	Unit	Edge
English	Stress-timed	Word	earlier
German	Stress-timed	Word	
Spanish	Syllable-timed	Syllable	

Present study

- First attempt to study emerging segmentation abilities in European Portuguese (EP) learning infants
- EP rhythm displays both stress and syllable timing properties, unlike English or Spanish (Frota & Vigário 2001)
- Also, unlike other languages, EP provides strong cues to high prosodic phrase boundaries and word boundaries, but not to lower phrase boundaries (Vigário, 2003; Frota 2014)

Aims

- Identify at what point in development segmentation abilities emerge

- Investigate whether **prosody** constrains early word segmentation abilities in EP in comparison with other languages
  - Monosyllabic segmentation earlier/later
  - Effect of prosodic salience (prosodic boundaries)

Two studies

EP learning infants' ability to segment monosyllabic word forms

STUDY 1

5-6 months and 8-9 months

STUDY 2

12 months

Method – Study 1 Participants

- 5-6 months:
  - 20 infants from monolingual homes in the Lisbon area (11 boys, mean age 6m 3d, range 4m 19d – 7m 11d)
  - 5 infants excluded due to fussiness (1), risk of autism (1), not needed (3)

- 8-9 months:
  - 20 infants from monolingual homes in the Lisbon area (12 boys, mean age 9m 2d, range 7m 27d – 10m 8d)
  - 0 infants excluded

Method – Study 1 Materials

- 4 monosyllabic pseudo words (CVC/CVG)
  - Ful, Queu, Pis, Sau
- 2 passages constructed for each word, one for middle and one for end sentences

Less Prominent

Internal to the Intonational Phrase (IP)

A Marta pôs o seu ___ na mesa.
Fizemos festas ao ___ vermelho.
Nunca comi ___ com morangos.
O Tó desenhou um ___ bonito.
Conheço ___ doce do Algarve.
Eles disseram ___ muitas vezes.

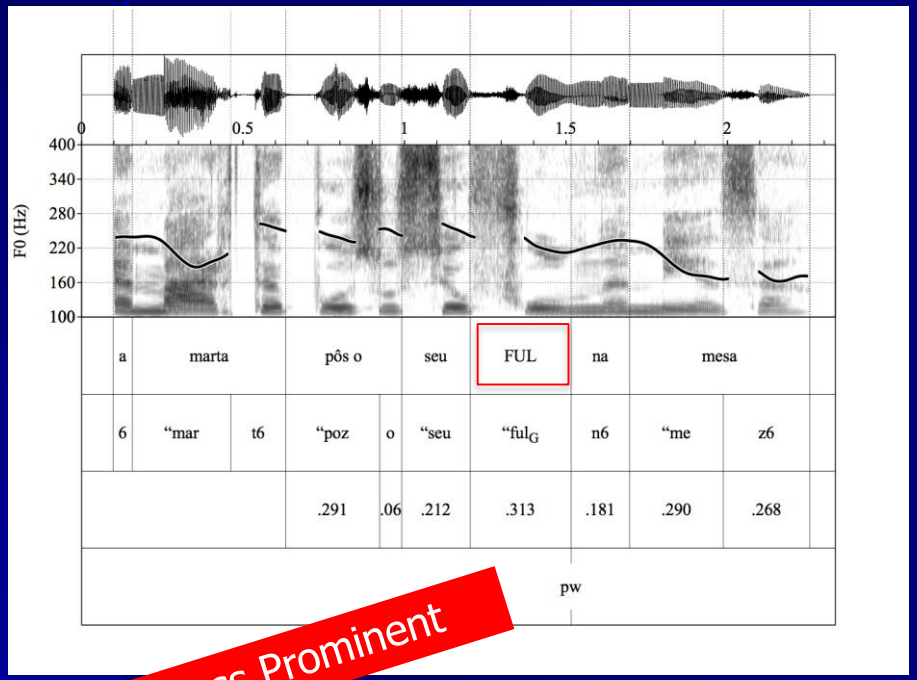
Prosodically Prominent

Final Intonational Phrase edge (=sentence)

Os vizinhos brincam com o teu ___.
Estão sempre a falar-nos do ___.
Elas viajavam muito de ___.
Os anões adoram bolachas e ___.
Quero agradecer tudo ao ___.
A Dora anda no seu grande ___.

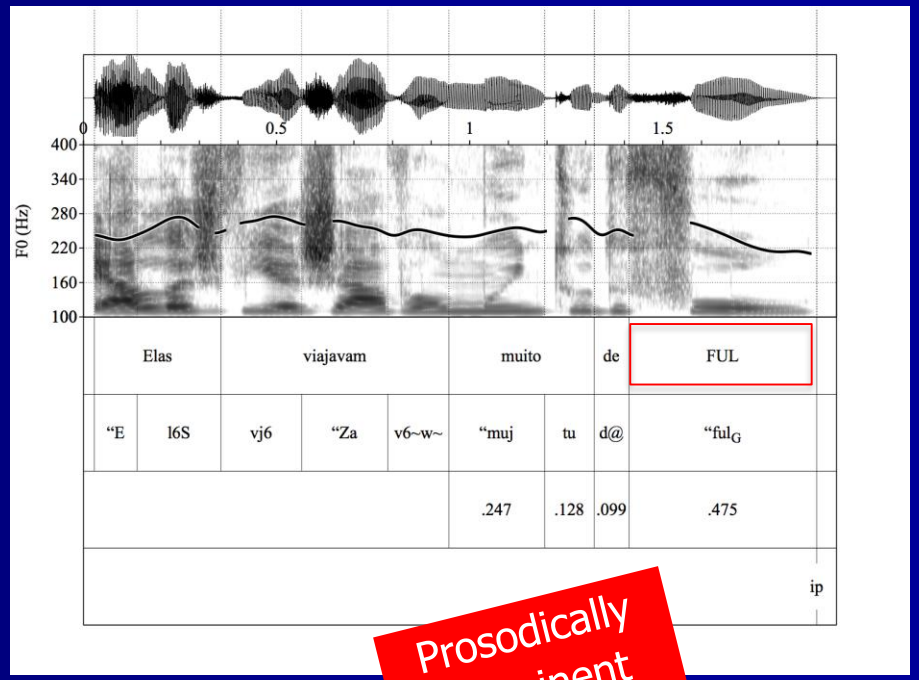
Method – Study 1

Internal to the Intonational Phrase (IP)



Less Prominent

Final Intonational Phrase edge (=sentence)



Prosodically Prominent

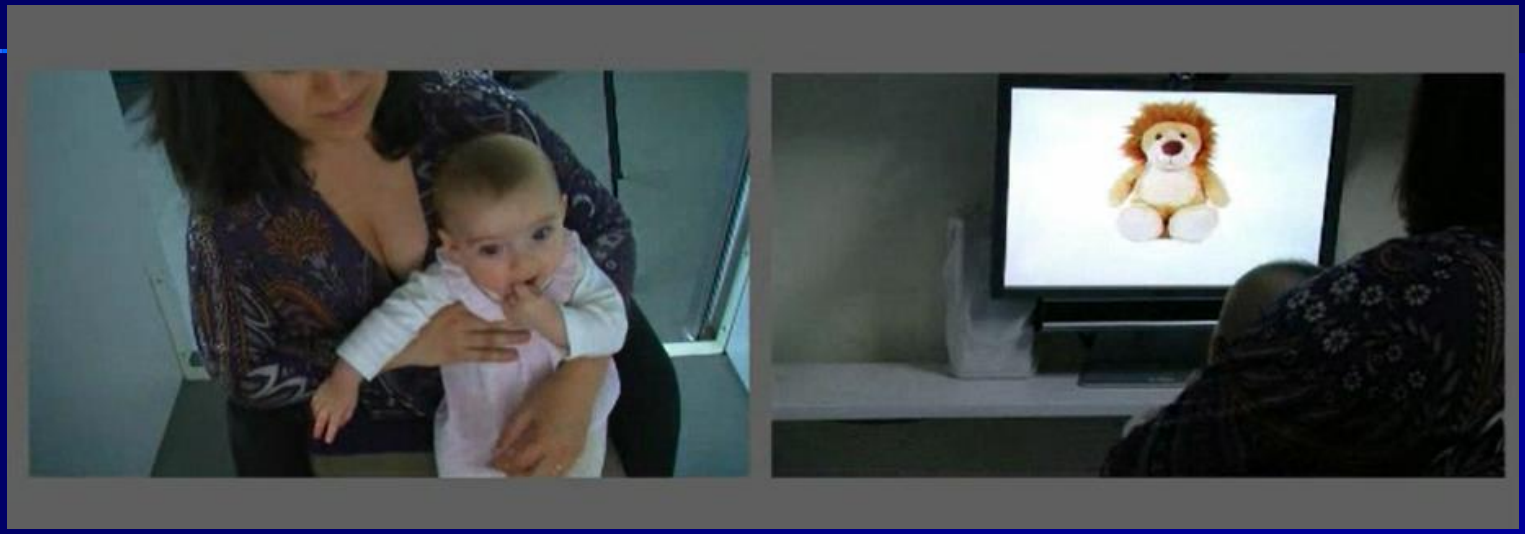
Method – Study 1

	Medial		End		
	Mean	SD	Mean	SD	
Sentence Length (ms)	2000.63	143.36	1952.88	154.91	1.11, $p = .27$
Syllable Duration Before Boundary (ms)	308.79	52.49	494.50	53.60	12.13, $p < .001$
Syllable Duration After Boundary (ms)	203.46	67.98	-	-	-
Pitch Range (hz)	-24.52	32.32	-59.58	21.83	4.4, $p < .001$
Pitch Reset (HZ)	-17.75	39.04	-	-	-
Tonal Event	-		L%		-

Method – Study 1

	Medial: PhP		Medial: PW		
	Mean	SD	Mean	SD	
Sentence Length (ms)	2022.69	94.20	1974.55	187.73	.81, p = .43
Syllable Duration Before Boundary (ms)	326.77	46.50	287.55	53.16	1.93, p = .07
Syllable Duration After Boundary (ms)	162.62	35.15	251.73	66.45	4.2, p < .001
Pitch Range (hz)	35.95	16.83	36.99	17.87	.15, p = .89
Tonal Event	-		-		-

Procedure: modified version of the Visual Habituation Paradigm (Stager & Werker, 1997; Altvater-Mackensen & Mani, 2013)



Method Study 1

Familiarisation

Alternating trials

25 secs accumulated listening time to each

Passage 1 – End

Passage 2 – mid

Test

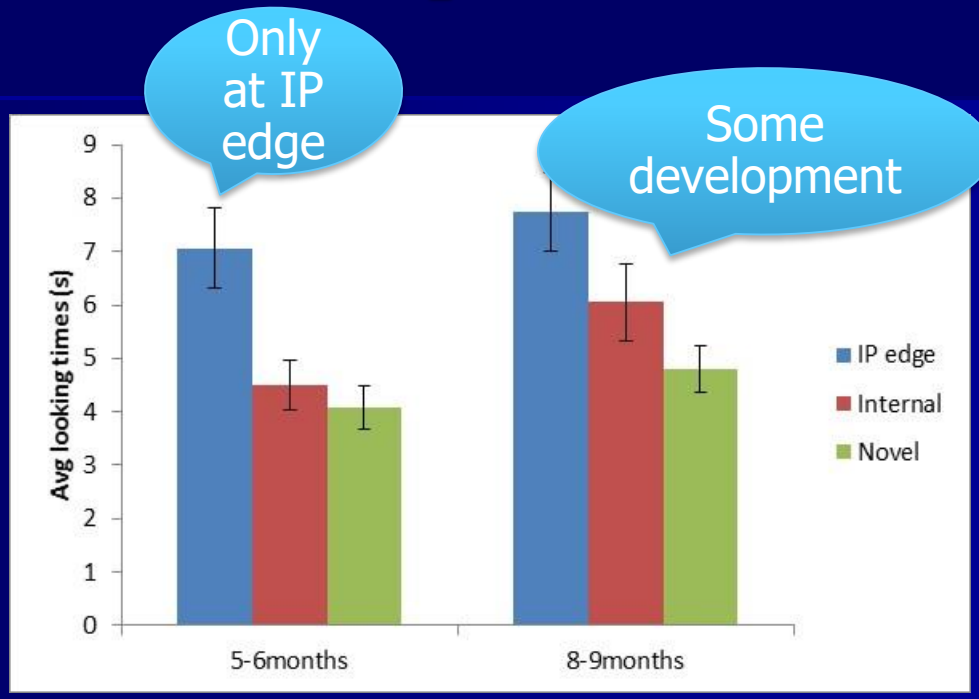
Block 1	Block 2	Block 3
Randomised order	Randomised order	Randomised order
Word 1 – familiar end	Word 1 – familiar end	Word 1 – familiar end
Word 2 – familiar mid	Word 2 – familiar mid	Word 2 – familiar mid
Word 3 – novel	Word 3 – novel	Word 3 – novel
Word 4 – novel	Word 4 – novel	Word 4 – novel

Trials continue until infant looks away for more than 2 consecutive seconds, or the sound file ends

Segmentation demonstrated by longer looking times to familiar word forms compared with novel

Results Study 1

Internal collapses lower prosodic boundary with just a word boundary



5-6 months:

- Significant effect of item status ($F(2,38) = 13.24$, $p < .001$, $\eta^2 = .41$).
  - end and middle ($t(19) = 3.38$, $p < .01$)
  - end and distracter ($t(19) = 4.72$, $p < .001$)
  - middle and distracter ($t(19) = .91$, $p = .37$).

8-9 months:

- Significant effect of item status ($F(2,38) = 16.72$, $p < .001$, $\eta^2 = .47$).
  - end and middle ($t(19) = 3.44$, $p < .01$)
  - end and distracter ($t(19) = 6.71$, $p < .001$)
  - middle and distracter ($t(19) = 2.12$, $p < .05$).

Method – Study 2 Participants

- 12 months (medial IP):
  - 20 infants from monolingual homes in the Lisbon area (10 boys, mean age 12m 2d, range 10m 24d – 13m 19d)
  - 2 infants excluded due to fussiness

- 12 months (medial PW):
  - 20 infants from monolingual homes in the Lisbon area (11 Boys, mean age 12m 10d, range 10m 15d– 14m 22d)
  - 3 infants excluded, 2 due to fussiness, 1 experimenter error

Method Study 2 Materials

- Same 4 monosyllabic pseudo words
  - Ful, Queu, Pis, Sau

Prosodically Prominent

Sentence internal Intonational Phrase edge

As rãs gostam de ___, em vez de musgo fresco.
Comprado o ___, voltamos ao parque.
Desde que viu o ___, não quis brincar mais.
Oferecemos-te ___, mas ficaste triste.
Quanto à luz ___, nunca foi testada.
Vocês prendem o ___, porém ele fugiu.

NO pause

- Procedure similar as for younger age groups
  - Only familiarised with words in middle of sentences

Method Study 2 Materials

- Same 4 monosyllabic pseudo words
  - Ful, Queu, Pis, Sau

Non-prominent internal position, with absence of any phrase boundary

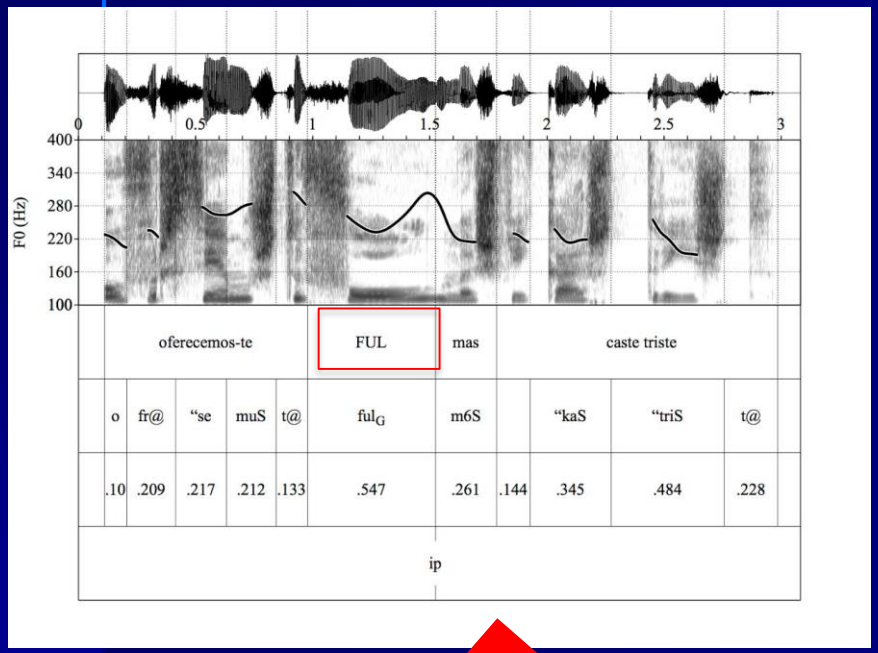
NOT Prominent

A caixa contém **ful** vermelho na tampa.
Aquele grande **ful** branco é da Quica.
Comeram muito **ful** doce na praia.
Hoje vi um **ful** castanho mas duro.
O amigo do **ful** português fugiu.
O outro **ful** branco foi de mercedes.

- Procedure similar as for younger age groups
  - Only familiarised with words in middle of sentences

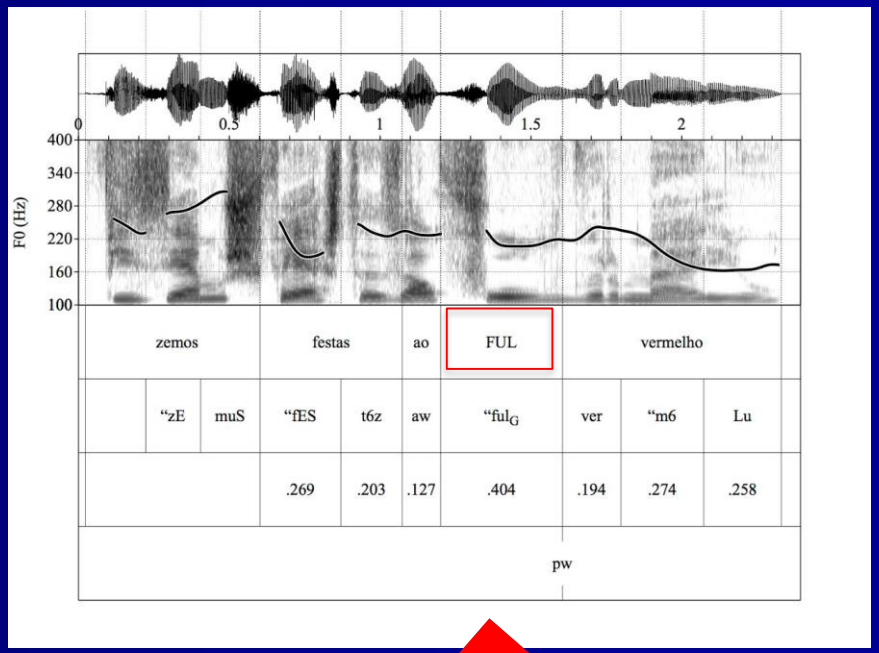
Method – Study 2

Sentence internal Intonational Phrase edge



Prosodically Prominent

Non-prominent internal position, no phrase boundary

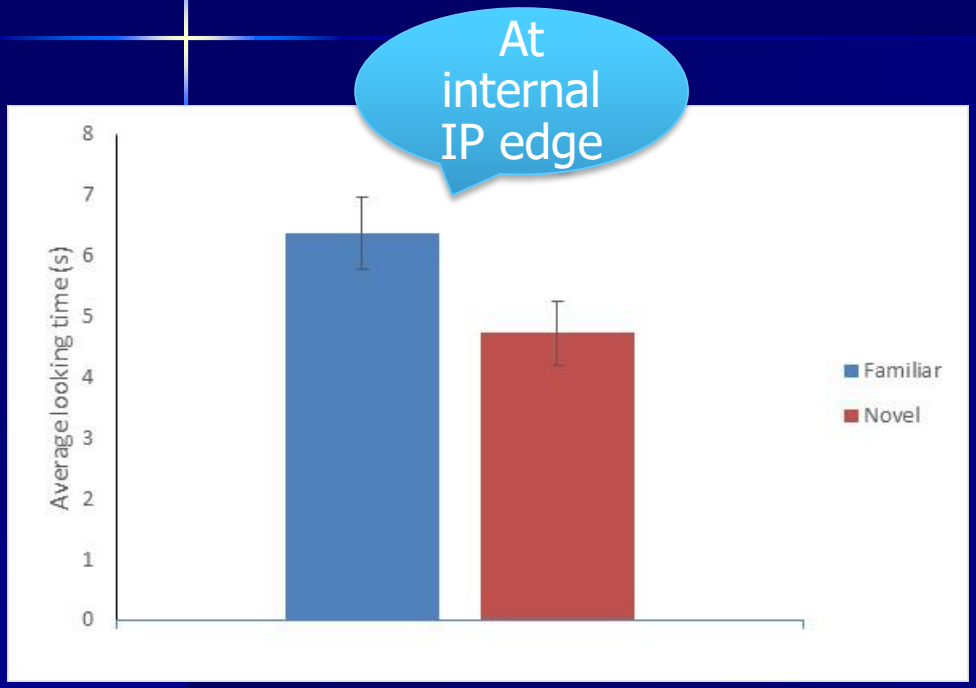


NOT Prominent

Method – Study 2

	IP Boundary		PW Boundary		
	Mean	SD	Mean	SD	
Sentence Length (ms)	2740	220	2320	220	6.34, $p < .001$
Syllable Duration Before Boundary (ms)	540	40	290	30	22.91, $p < .001$
Syllable Duration After Boundary (ms)	230	50	260	60	1.71, $p = .1$
Pitch Range (hz)	85.92	37.43	-29.59	14.06	14.47, $p < .001$
Pitch Reset (HZ)	-93.45	34.06	-30.58	21.55	7.75, $p < .001$
Tonal Event	H%		-		-

Results Study 2

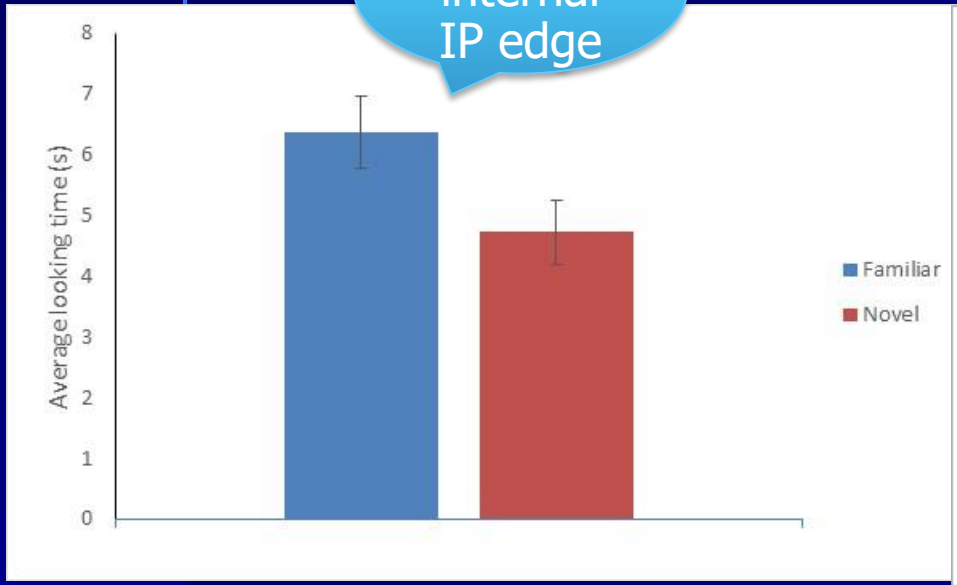


Similar behaviour, segmentation wise, to 5-6 month olds at final IP boundaries (=sentence edge)

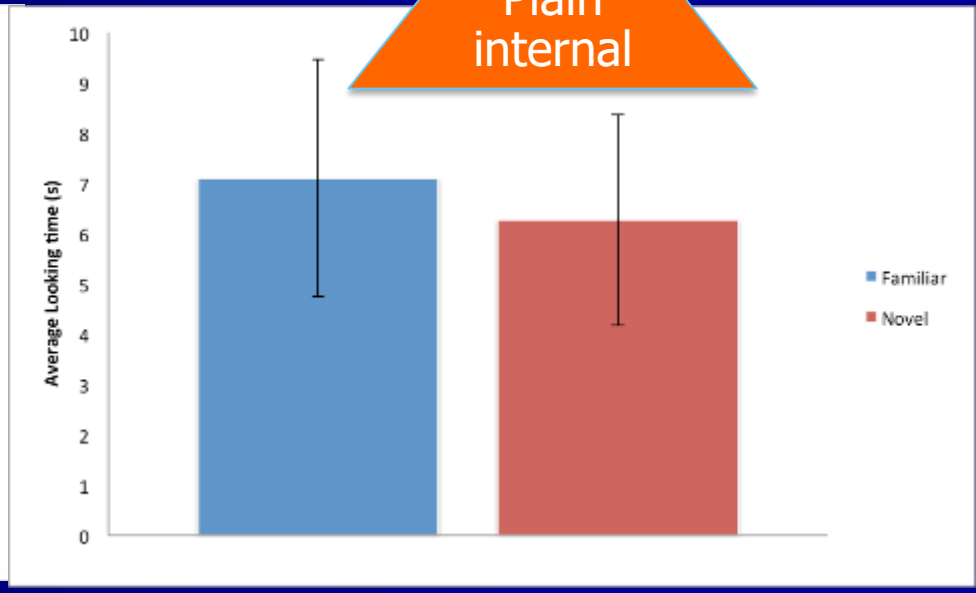
- Significant effect of item status - $F(1,18) = 23.6$, $p < .001$, $\eta^2 = .57$

Results Study 2

At internal IP edge



No! Plain internal



- Significant effect of item status - $F(1,18) = 23.6$, $p < .001$, $\eta^2 = .57$
- No significant effect of item status - $F(1,18) = 1,776$, $p > .1$, $\eta^2 = .090$

Conclusions

- EP learning infants at 5-6 months are able to segment continuous speech only when the word is located at the high prosodic edge (**IP boundary**, the end of the sentence)
  - In line with recent findings for English learning infants, but against those for Spanish/Catalan infants showing segmentation at 6 months regardless of prosody

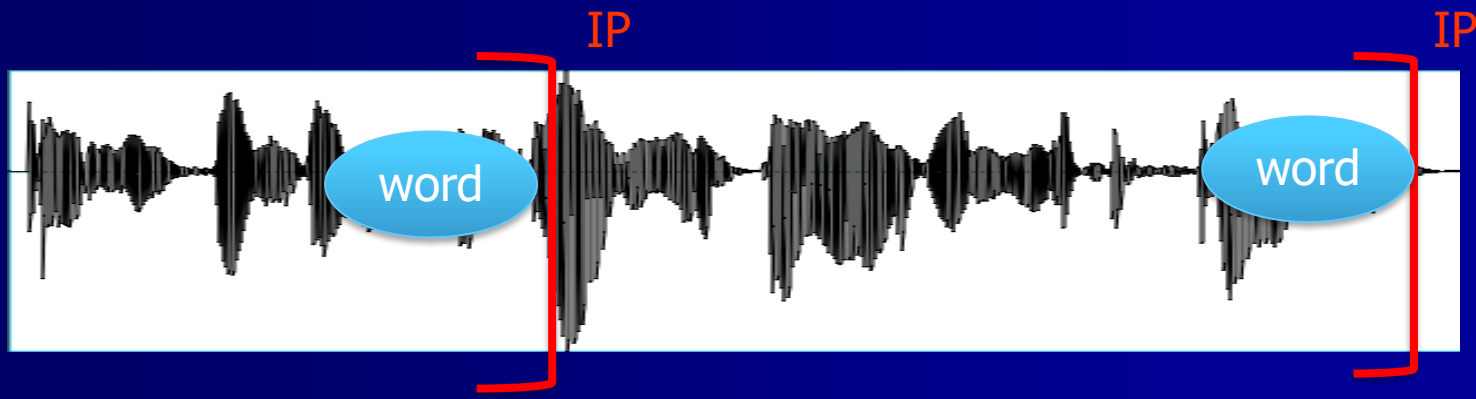
- At 8-9 months, EP infants start to segment words in the middle of sentences (lower boundaries), but still demonstrate an advantage for words at the end of sentences

Conclusions

- Portuguese 12-month-old infants are able to segment words in sentence **medial** position, when target word precedes a **IP boundary** (despite the absence of a pause)
- This shows a sensitivity to prosody in early segmentation, beyond the edge vs. internal position

Prosody matters!

Prosody constrains the emergence and development of early segmentation in EP, in the first year



Thanks to all the infants, families and nurseries that have taken part in these studies.

Obrigada!

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EBELa: EXCL/MHC-LIN/0688/2012
SFRH/BD/80991/2011

Conclusions

- These findings add to our existing knowledge of the emergence of segmentation abilities
  - What cues constrain, or are utilised, during the development of this ability.
- New findings in a prosodically 'atypical' language, EP, not previously studied for word segmentation.